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Rainfall probability analysis and crop planning for Chambal region of Madhya Pradesh

H.S. BHADORIA, H. SINGH AND A. SINGH

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See end of the Paper for authors' affiliation

Correspondence to:

H.S. BHADORIA,
College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,GWALIOR (M.P.) INDIA
Email :
hsbhadauria@rediffmail.com

ABSTRACT : Daily rainfall data of 29 years (1981-2009) recorded at RVSKVV, Zonal Agricultural Research Station Morena, Madhya Pradesh was examined for long term averages of annual, seasonal, monthly, and weekly rainfall and its temporal variability. Co-efficient of variation of 27.1 per cent indicated that the annual rainfall was more or less stable over the years. The season-wise per cent contribution of annual rainfall was 3.7, 7.9 and 88.4 per cent of summer, *Rabi* and *Kharif* seasons, respectively. With in the rainy season, August was the highest rainfall contributing month (33.4%) followed by July (28.9%) mean weakly, precipitation amount and its assurance reaches the peak (>50mm/week) during 26th SMW (Standard Meteorological Week) to 38th SMW and again declined thereafter. The earliest onset of rainy season occurred in 24th SMW. The normal onset of rainy season was observed as 26th SMW with CV of 5.8 per cent. There is an ample scope for rain water harvesting from July to September which can be utilized as crop saving irrigation as well as pre-sowing irrigation for succeeding *Rabi* crops which are generally sown on residual soil moisture.

KEY WORDS : Rainfall pattern, Probability analysis, Crop planning

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Agriculture being mainly rain fed, the Gird Agro climatic zone of Madhya Pradesh state, India locally known as 'Kandi' (Alluvial) is characterized by undulating to escapement topography, uneven and erratic distribution of rainfall, deep ground water table, severe soil erosion, inherent poor soil fertility and frequent crop failures. Since rainfall is the only source of moisture, the spatiotemporal distribution of rains holds the key in determining the fate of entire crop productivity in the region. Knowledge of average monthly, seasonal and annual rainfall is helpful in understanding the general picture of the particular region but the weekly rainfall data analysis gives more useful and precise information's for the rainfall based crop planning (Tiwari *et al.,* 1992). Rainfall probability (wet and dry spells) could made use of in selection of different cropping system (Jadhav *et al.,* 1999). The coincidence of wet spells with the sensitive phenophases sometimes may be more detrimental to the crop development. On the other hand, the occurrence of dry spell at the time of ripening would become beneficial. Therefore, the probability of wet and dry spells can serve as a basic input for establishing precise crop-weather relationships to take some useful decision for crop management practices, contingent crop planning and related farm operations for sustaining crop production in the area. Such an analysis has also been reported from other parts of the country to follow a profitable crop planning system under rainfed conditions (Sarnia *et al.* 1996 and Dingre and Habib, 2006). Hence, an attempt has been made to analyze the daily rainfall data of ZARS, Morena for evolving rainfall based cropping system.

METHODOLOGY

The daily rainfall data for 29 years (1981-2009) recorded at Agro-meteorological Observatory (31^{0}6'5"N, 76^{0}27'26"E and 152-529 m above mean sea level), RVSKVV, Zonal Agricultural Research Station for Chambal Command Area (ZARS) of RVSKVV Gwalior, Madhya Pradesh was examined for analyzing rainfall distribution pattern of the area, probability of wet and dry spells and its implications for crop planning. An attempt has been made to use a standard week in drought analysis using Markov Chain Model and planning crops accordingly. A week receiving less than 21 mm rainfall is taken as dry spell week and week receiving 21 mm or more rainfall as a wet week (Subramaniam and Raju, 1988). From the daily rainfall data, annual, seasonal, monthly and weekly total rainfall was worked

out for the year.

The probability of occurrence of a dry week {p(d)} and three consecutive dry weeks {p(ddd)} was computed by Markov Chain process (Robertson, 1976). Similarly, p(w), p(ww) and p(www) were calculated in the same way and the notations used are having the same meaning except the week being wet.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Annual rainfall :

The compilation of 29 years daily rainfall data of ZARS, Morena showed that the average annual rainfall of the station was 701.0 mm spread over 52 rainy days with 27 per cent coefficient of variation (CV) indicating low variability over the years (Table1). The rain fall was above normal in 14 years and blow normal in 15 years. The maximum and minimum rainfall of 343.6.1 and 1295.5 mm was recorded in the years 1987 and 1995 on 48 and 53 rainy days, respectively.

Seasonal rainfall :

The seasonal rainfall distribution (Table 1) in terms of summer (March to May), *Kharif* (June to September) and *Rabi* (October to February) seasons revealed that the region enjoys a well defined pattern of seasonal rainfall. The rainfall received was the highest in *Kharif* season (1086.5 mm) followed by *Rabi* with 227.5 mm. The season-wise per cent contribution to total annual average rainfall was 3.7, 7.9 and 88.4 per cent of summer, *Rabi* and *Kharif* seasons, respectively. The lowest CV recorded in *Kharif* (33.2%) indicates more reliable receipt of rainfall (Table 1).

Monthly rainfall :

The data on monthly rainfall (Table 1) revealed that August was the highest (223.9 mm). November was observed to be the least rainfall contributing month (0.7%). The period from June to August was the most dependable (CV range 35.54%) and the months of October to December were the most uncertain (CV range 162 – 182%).

Weekly rainfall :

The weekly average rainfall ranged from 0.4 mm (44th SMW) to 90.3 mm (31st SMW). Mean weekly precipitation amount and its assurance low during the initial 22 SMWs, reached the peak (> 50mm/week) during 27th SMW to 36th SMW and again declined thereafter. The weekly average rainfall during the monsoon season (June to September) was higher than other seasons varying from 15.7 mm to 90.3 mm. The CV values during monsoon season were relatively less (69-148%) owing to stable quantum of rainfall compared to the values of 131-456 per cent and 145-297 per cent in post and pre-monsoon weeks, respectively (Table 2). The higher values of CV in all weeks indicated that the rainfall was much erratic in distribution and it was higher in post monsoon weeks.

Probability of dry and wet spells :

The probability of occurrence of dry spells (Table 2) is as high as 84-98 per cent in the first 22 SMWs except for 2nd

Table 1: Average monthly and seasonal rainfall (mm) at Zonal Agricultural Research Station, Morena (1981-2009)

Months	Rain fall (mm) total (%)	Contribution to total (%)	C.V. (%)	Rainy days
March	5.2	0.8	68.1	1.6
April	7.1	1.0	90.3	2.0
May	12.6	1.9	95.4	1.1
Summer season	24.9	3.7	51.3	1.4
June	64.8	9.7	54.2	4.6
July	193.6	28.9	52.3	9.8
August	223.9	33.4	35.5	8.5
September	109.8	16.4	67.3	8.3
Kharif season	592.1	88.4	33.2	3.7
October	24.2	3.6	171.0	4.3
November	4.9	0.8	182.0	1.5
December	4.4	0.7	162.0	1.5
January	10.6	1.6	89.8	1.7
February	8.6	1.3	80.0	2.0
Rabi season	52.7	7.9	49.1	1.7
Grand total	669.7	100.0	27.1	4.8

Table 2: Mean weekly rain fall, its variability and probability of different dry and wet spell at Zonal Agricultural Research Statoin, Morena (1981-2009)

SMW	Rainfall (mm)	P (d)	P (dd)	P (ddd)	P (ww)	P (ww)	P (www)
1	6.8	84	70	50	12	0	0
2	7.9	79	65	65	17	4	0
3	5.7	84	65	65	22	4	0
4	5.4	85	79	70	4	4	0
5	6.6	86	84	50	12	4	0
6	9.2	79	70	50	17	0	0
7	11.1	89	55	55	17	0	0
8	14.7	84	60	60	22	4	0
9	7.0	84	69	70	12	0	0
10	12.1	93	79	80	4	0	0
11	6.1	98	73	73	0	0	0
12	5.8	88	87	69	8	0	0
13	3.7	88	79	69	8	0	0
14	6.8	88	79	74	8	0	0
15	1.1	84	79	74	12	0	0
16	3.9	98	84	74	0	0	0
17	8.7	93	84	79	4	0	0
18	5.8	79	79	79	17	8	0
19	8.2	88	84	74	8	0	0
20	6.5	88	72	74	8	0	0
21	14.8	93	79	55	4	0	0
22	16.8	84	79	35	12	8	0
23	20.1	65	60	22	31	4	0
24	39.7	74	35	36	22	17	8
25	50.0	60	45	22	36	27	8
26	66.8	27	15	17	69	40	34
27	56.7	27	0	4	69	50	40
28	66.5	27	3	0	69	65	50
29	75.0	17	8	0	79	60	55
30	90.4	12	8	0	84	65	55
31	83.1	17	0	0	79	70	60
32	68.9	17	4	0	79	65	46
33	53.9	12	0	0	84	60	46
34	63.2	31	4	0	65	50	34
35	65.8	17	4	0	79	50	12
36	18.4	36	12	0	60	17	0
37	34.9	65	22	8	31	4	0
38	14.8	60	31	8	36	4	0
39	5.8	74	56	22	22	18	0
40	12.7	84	65	65	12	4	0
41	12.5	84	79	65	12	0	0
42	0.9	88	65	65	8	0	0
43	0.5	98	79	79	0	0	0
44	0.9	98	98	98	0	0	0
45	11.8	93	93	84	4	0	0
46	0.5	98	93	84	0	0	0
47	6.9	84	79	79	12	0	0
48	2.0	98	84	84	0	0	0
49	10.7	93	92	79	4	0	0
50	6.7	98	92	69	0	0	0
51	3.7	84	79	74	12	0	0
52	6.9	84	70	65	12	0	0

and 6th SMW where it was only 79 per cent of getting a dry week. Thereafter, the values remain low between 26th to 33rd SMW (representing wet spell sequence) and then again continue to increase till the end of the year. On the other hand, the probability of ketting rainfall (wet spell) remains very high (71-86%) during 26th to 35th SMW except for 34th SMW. The probability of getting a wet spell, two and three consecutive wet spells are low during the first 25 SMWs. The values remained high during 26th to 35th SMW and again very low from 36th SMW till the end of the year. The probability of getting a month being dry remains in the range of 85 – 100 per cent for the entire pre and post monsoon season months . However, the months of July and August were found to have 95-100 per cent assured rainfall followed by September (75 %) and June (45%).

Crop planning :

Based on the above analysis, the following recommendations for the region could be made to increase the crop production per unit area under rainfed conditions. About 80 per cent of the total average annual rainfall coincides with *Kharif* season and is received during a short time span of two and half months between July to September due to south-west monsoon. Rainfall received during April–May can be utilized for summer ploughing to make the land ready for final field preparation. The earliest start of rainy season had occurred in 24th SMW (June 11-17) and delay in start was as late as 29th SMW (July 16-22). The normal start of rainy season was observed as 26th SMW (June 25-July 1) in the region with coefficient of variation of 5.2 per cent. With the normal onset of rainfall, sowing of main season *Kharif* crop like pearlmillet and jawar (JVV 2, JJ 1048) should be started from the forth fortnight of June. In case of delayed start, short duration drought tolerant maize varieties (JM 8, JM 12) and low water requiring crops like oilseeds (mustard jm 1, Pusa bold, Rohini) and pulses (greengram-KMT 7, MA 3, MA 4/GRAM-JGK 1, JGK 3) should be grown accordingly. In the event of mid season drought, mulching will help in reducing soil evaporation and conserving moisture in top layers of the soil. In the event of terminal drought, receding soil moisture conditions, crop requires supplementary irrigation. Intercropping of maize (50/60cm) with pulses (greengram/ blackgram) in 1:1 row proportion can be viable option for increasing per unit area crop productivity under rainfed conditions.

A major portion of monsoon rainfall is generally lost through runoff (25-35%) which can be stored through the construction of suitable water harvesting structures as on-farm reservoirs. The rainfall received during October-November is only 4-5 per cent of the total average annual rainfall which is very low for the sowing of *Rabi* season crops. Therefore, soil and moisture conservation measures need due attention to conserve rainwater particularly during the months of July to September. Sowing of main *Rabi* season crops like wheat (PBW 343 and PBW 527) and mustard (Pusa bold, Rohini) should be started from the last week of October. In case, the timely sowing of *Rabi* crops is not done due to inadequate soil moisture, then wheat varieties like PBW 373 and PBW 509 and mustard like JM 2 could be sown with the receipt of late winter showers for taking remunerative crop yields.

Authors' affiliations:
H. SINGH AND A. SINGH, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, GWALIOR (M.P.) INDIA

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